Energy Management at Taj Bengal Hotel, Kolkata

Prepared for Taj Group of Hotels
Mumbai

TERI Project Report No. 2002IE64

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1

Energy Management at Taj Bengal, Kolkata

Introduction

In order to optimise energy use in various energy consuming equipment and systems at Taj Bengal, Kolkata, a detailed energy audit was conducted by Tata Energy Research Institute (TERI), New Delhi in the year 1999-2000. In it's report TERI had recommended several energy conservation options to help save energy and enhance system efficiency at Taj Bengal. The Taj Group of Hotel's management is very keen to know that how this optimisation process is being carried out in the unit. They want a review of tasks, which are already accomplished, tasks that are pending, constraints in implementing proposed measures and how they are helping in bringing down the energy consumption level without compromising the very high standards which are maintained in the Taj Hotels. Keeping this mind a study has been carried out and findings of the study are presented below.

Added electrical load and addition in electricity consumption

There are two main areas where extra load has been added since 1999-2000. One more air-handling unit of 37.5TR capacity with 15 kW motor load has been added to recently renovated coffee shop (The Hub). This would consume approximately 52000 kWh per year. Approximately 74 kW is added in kitchen in form of kitchen equipment and that would consume around 1,95,000 kWh per year. Hence the added electrical load has increased the electricity consumption by 2,47,000 kWh/year.

Total electrical added after 1999-2000	:	89 kW
Addition in electricity consumption due to added load	:	247000 kWh

Electricity consumption

The monthly consumption of last three years is shown in Table 1 below.

Table-1. Monthly electricity consumption (kWh) at Taj Bengal, Kolkata

Month	*1999-2000*	*2000-2001*	*2001-2002*
April	1010800	980732	980400
May	956933	1012066	1044600
June	991066	993466	975933
July	1050732	1019000	999706
August	1055000	1012800	999706
September	964120	967773	967933
October	926533	917800	903000
November	800333	793933	713000
December	787400	767400	670400
January	749400	721000	678400
February	720266	736267	661000
March	851800	900500	837250
Total	10864383	10822737	10431328

If we compare the 2001-2002 electricity consumption with 1999-2000 consumption, we find that there is approximately 4, 33, 055 kWh reduction in electricity consumption. If the added consumption due to added load is also included the total saving is found to be around 6,80,055 kWh or 6% of the total electricity consumption.

Achieved saving in electricity consumption after 1999-2000 : 680055 kWh
Achieved saving in electricity : 6% of total electricity consumption
Electricity consumption trend : (-) 3% per year

LDO consumption

The monthly consumption of last three years is shown in Table 2 below.

Table-2. Monthly LDO consumption (litre) at Taj Bengal, Kolkata

Month	*1999-2000*	*2000-2001*	*2001-2002*
April	47844	47088	45928
May	47837	46764	47354
June	46692	45556	45088
July	51156	49305	45640
August	52776	50650	45880
September	50122	48766	43504

Month	*1999-2000*	*2000-2001*	*2001-2002*
October	53136	46620	45588
November	49994	46584	40989
December	52164	52904	49970
January	50904	53152	48853
February	50443	48284	44492
March	49960	49641	50838
Total	603028	585314	554124

If we compare the 2001-2002 LDO consumption with 1999-2000 consumption, we find that there is approximately 48904-litre reduction in LDO consumption or 8% of the total LDO consumption.

Achieved saving in LDO consumption after 1999-2000	:	48900 litre
Achieved saving in electricity	:	8% of total electricity consumption
Electricity consumption trend	:	(-) 4% per year

HVAC systems

Chilling Plants

When audit was conducted in 1999-2000, the chilling plants found to be operating at an average efficiency of 0.765 kW/TR as compared to the rated 0.672 kW/TR. It was also estimated that by improving the efficiency of plants through proper maintenance and controls a saving of around 2,25,000 kWh could be realised per year. During this visit we have noticed that not much has been done in this regards except the plants insulation have been redone in order to reduce the structural heat gain. This might lead to increase in operating plant efficiency.

At peak time, when the ambient temperature remains around 39 to 43 ° C and humidity around 90%, it has been observed that even though three plants operate, the supply chilled water temperature could not be dropped below 12 to 12.5 ° C. This is a clear reminder that the existing plants are not able to take peak load. When discussed with engineering staff, they too feel that there is a need of an extra chiller of at least 300 TR with the existing load.

However, they also seemed very confident to meet the reduced peak load after implementing various load reduction measures which they are currently installing and mentioned below.

Load reduction measures

- All the guest room windows on 3rd, 4th, and fifth floors are replaced with doubly glazed windows and very soon the windows of guest rooms on 1st and 2nd floors will also be replaced with doubly glazed windows. This will not reduce the infiltration loses but also reduce the thermal losses to the great deal. Since in guest rooms the major contribution to the cooling load are glazing, our previous experience and analysis show that it will reduce the existing cooling load by 10% and hence a saving of 10% in HVAC consumption will be realised.
- Single swings pool entrance gate is converted into double door to reduce the ex-filtration when AHUs are on and infiltration losses when AHUs are off. Similarly Taj Bengal management plans to replace the single door at banquet entrance with double door. Its very difficult to quantify the savings by these measures but a 5% saving will definitely be realised.

Chilled water line & chilled water pumps

In the existing chilled water system the primary pumps first pump the chilled water from chillers to the overhead chilled water tanks no-1 & no-2 at the terrace. From terrace the chilled water again comes down to the suction of the primary pumps installed at basement and from there it is circulated through five zones with the help of secondary pumps and again collected at over head tanks no-3 and no-4 at the terrace. From chilled water return overhead tanks it flows down to basement at primary pumps suction. In this process it has been observed that there is a drop of 1 ° F between supply chilled water at the chiller outlet and the secondary pumps suction. This is enormous waste of energy.

Furthermore all pumping systems are sized for maximum flow required and the total head. Hence, constant speed pumps operating at less than peak design conditions require relatively unchanged input energy. At Taj Bengal hotel where the space cooling load fluctuates depending on the ambient conditions, operational schedule, occupancy and lighting load, the cooling required at different hours is different from the peak load conditions. No doubt at loads less than the peak loads, the chillers start getting down loaded but chilled water system, which is designed for constant flow continues to circulate the same amount of chilled water as it does at peak load conditions. This leads to a significant wastage of pumping energy. In order to counter these problems a modified chilled water system is recommended. The modified chilled water system designed in such a way that it circulates the constant flow in the primary circuit through the operating chillers. The secondary circuit or the distributing chilled water system caters to the different load centres and operates at variable flow in proportional to the current space load and it designed for the total flow and head generated in secondary circuit.

The recommended two loop chilled water system is shown in Figure 1 &2. Now the chilled water from chillers is not pumped to the over head tanks, instead it is directly made available at the secondary pumps suction with a bypass. These secondary pumps are fitted with variable speed drives. Any unwanted chilled water is bypassed to the primary loop. The return water from zones B, C, D, E again not pumped to the overhead tanks instead it is collected and made available at the primary pump suction with by passed chilled water line joining this line in between.

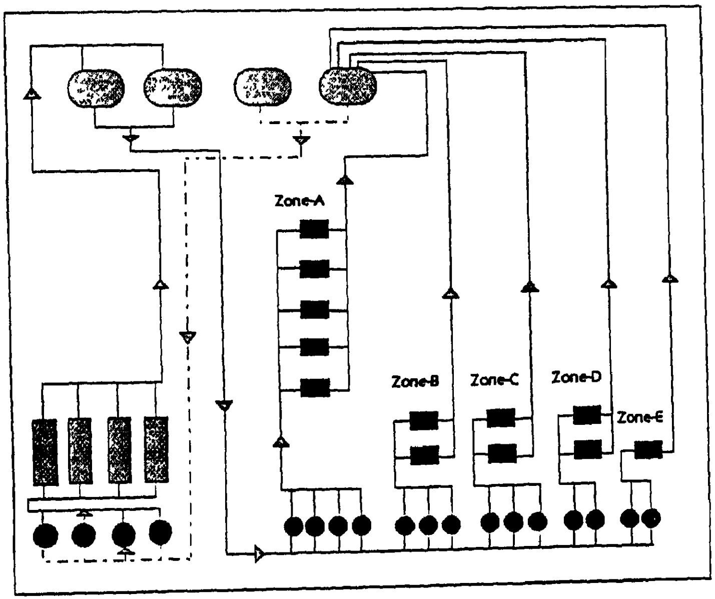

Figure 1. Existing chilled water system

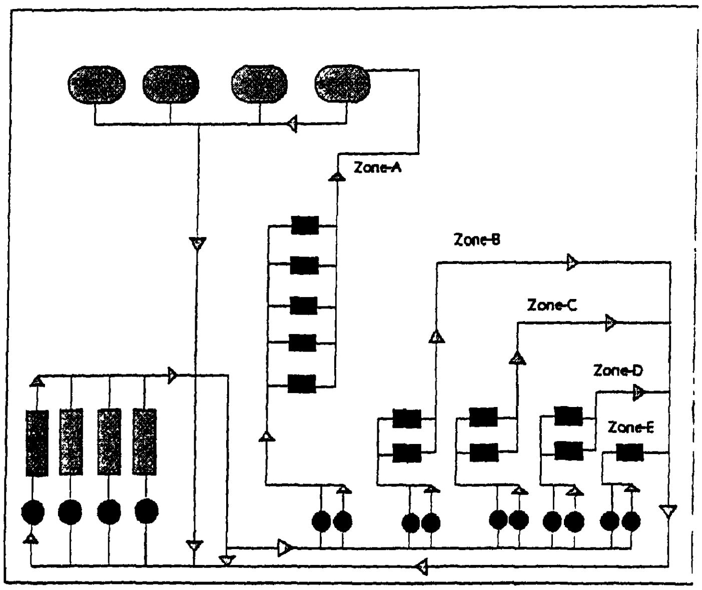

Figure 2. Modified chilled water system

Recommended action plan

1. Covert constant chilled water system with variable chilled water systems as shown above.
2. Redo the piping analysis and size the primary as well as secondary chilled water pumps for new discharge and head.
3. Dismantle the existing low efficiency primary & secondary pumps and install appropriately sized new generation high efficiency pumps.
4. Y K Jain, consulting engineers, New Delhi has carried out a detailed analysis of this conversion and we strongly recommend the implementation of this measure. The total estimated cost of the project is around Rs 37 lakhs with a payback period of well within one year. When discussed with chief engineer he is very confident of doing it in one month and project can be taken up during winter.

Pumping systems

Grundfos has carried out a study and suggested the replacement of various inefficient pumps installed at Taj Bengal with their new generation high efficient pumps. They have also given their offer with complete economic analysis. We very strongly recommend the implementation of this measure since it will yield a substantial amount of saving in pumping systems.

A brief summary of the report is presented here for various pumps

S No	Pump	Quantity	BkW saved per day	Amount saved per year (Rs)	Initial cost (Rs)	Payback period (yrs)
1	Condenser water pumps	4	156	398580	377100	0.9
2	ROC booster	2	10.56	26980	38600	1.4
4	ROC primary	2	74.16	189480	87760	0.5
6	SC primary	2	30.38	77620	81200	1.1
8	SC secondary	2	15.04	38430	67400	1.8
10	Traulsen	3	28.8	73400	94800	1.3
13	ROH primary	3	38.52	98420	87760	0.9
15	ROH secondary-1	3	40.56	103630	100000	1.0

The total replacement cost would be around Rs 9.5 lakhs and that would help in saving approximately Rs 10 lakhs per year.

Electrical systems

In last energy audit it has been observed that a lot of motors were operating at part load leading to the wastage of significant energy. Following recommendations were made for oversized motors to replace with undersized motors.

- Since the under loaded motor has lower motor efficiency and poor power factor, it is recommended that 33 motors at Taj Bengal which are loaded below 50% should be replaced with appropriate sized motors.
- The laundry exhaust –2, 3 & 4 fan motors that are of 11 kW rating should be replaced with 5.5 kW motor.
- Nightclub exhaust fan motor of 3.7 kW rating should be replaced with 1.1 kW motor.
- Bakery exhaust and Public toilet exhaust -1 fan motors of 3.7 kW rating should be replaced with 2.2 kW motor.
- Public toilet exhaust –2 fan motor and GRX –2 motor of 3.7 kW rating should be replaced with 1.5 kW motor.
- Indian kitchen supply fan-1 motor and Chinese kitchen supply fan motors of 7.5 kW rating should be replaced with 3.7 kW motor.
- Indian kitchen supply fan –2 motor of 7.5 kW rating should be replaced with 1.5 kW motor.
- Bakery supply fan motor that is of 5.5 kW rating should be replaced with 3.7 kW motor.
- ROC booster pump no-1 motor that is of 3.7 kW rating should be replaced with 1.1 kW motor.

- ROC booster pump no-2 motor that is of 3.7 kW rating should be replaced with 1.5 kW motor.
- Chinese restaurant AHU fan motor, Foyer AHU fan motor, Crystal west AHU fan motor, Crystal East AHU fan motor and Crystal central AHU fan motor which are of 11 kW rating should be replaced with 3.7 kW motors.
- Sonargaon Restaurant AHU fan motor, Pre-function AHU fan motor, Shopping –2 AHU fan motor and Junction bar AHU fan motor which are of 7.5 kW rating should be replaced with 2.2 kW rating motor.
- Coffee shop AHU-1 fan motor and Back office AHU fan motor which are of 11 kW rating should be replaced with 2.2 kW motor.
- Administration AHU fan motor that is of 7.5 kW rating should be replaced with 1.5 kW rating motor.
- Lobby Atrium AHU-2 fan motor that is of 15 kW rating should be replaced with 7.5 kW rating motor.
- Lobby Atrium AHU – 1 fan motor that is of 15 kW rating should be replaced with 1.5 kW rating motor.
- Lobby corridor AHU fan motor that is of 15 kW rating should be replaced with 1.1 kW rating motor.
- Coffee shop AHU–2 fan motor that is of 5.5 kW rating should be replaced with 2.2 kW rating motor.
- There exist a potential to save around 44360 kWh or Rs. 2 lacs annually by replacement of under loaded motors with appropriate sized motors.

However, during present it was observed that out of 33 motors only 9 motors have been replace which are given below:

- In coffee shop AHU-2, 15-hp motor has been replaced with 7.5-hp motor.
- In Crystal central AHU, 15-hp motor has been replaced with 7.5-hp motor.
- In Crystal foyer AHU, 15-hp motor has been replaced with 7.5-hp motor.
- In Chinese kitchen, 11-kW motor of supply fan has been replaced with 5.5-kW motor.
- In Sonargaon kitchen, two 11-kW motors of supply fans have been replaced with two 5.5-kW motors.
- In Banquet kitchen, 15-kW motor of supply fan has been replaced with 5.5-kW motor.
- In Bakery, 11-kW motor of supply fan has been replaced with 3.7-kW motor.
- In Room service kitchen, 11-kW motor of supply fan has been replaced with 5.5-kW motor.

Recommended action

Expedite the motor replacement which will require and initial investment of Rs 2.0 lakhs and get it done before plan to install any variable frequency drive on fan.

Air Handling Units

As recommended earlier variable frequency drives (inverters) have been installed in following air-handling units and they are contributing to approximately 12% savings in those AHUs.

- Gent's health club
- Ladies' health club
- Coffee shop-1
- Lobby corridor
- Lobby corridor (back office)
- Bell captain

Supply air and exhaust systems

During last study it was found that by installing frequency drives in supply air and exhaust fans and schedule their operation at different frequencies depending on the load, considerable amount of energy can be saved. Following recommendations were made.

Room service

Install VFD on fresh air fan and it should be operated at 30 Hz through out the year. The operating supply air CFM would be 6287 (70% of the present operating CFM) and that would be less than the exhaust (6402-CFM)). The saving potential is given below.

- Annual energy consumption without VFD : 32733 kWh
- Annual energy consumption with VFD : 9820 kWh
- Annual energy saving : 22913 kWh
- Annual saving in energy cost : Rs 112270
- Initial investment required : Rs 75000
- Simple payback period : 8 months

Chinese kitchen

VFD should be installed at fresh air fan and it should be operated at 30 Hz through out the year. The operating supply air CFM would be 5220 (70% of the present operating CFM) and that would be less than the exhaust (6036-CFM)). The saving potential is given below.

Annual energy consumption without VFD : 18570 kWh
Annual energy consumption with VFD : 5570 kWh
Annual energy saving : 13000 kWh
Annual saving in energy cost : Rs 63700
Initial investment required : Rs 75000
Simple payback period : 1.2 yrs

Indian kitchen

- One exhaust fan and one fresh air fan should be operated
- VFDs should be installed at the exhaust fan as well supply fan

Table 3. Saving potential (exhaust fan)

Schedule	*Hz*	*CFM %*	*kW %*	*CFM*	*kW required*	*kWh consumed*
9 AM to 11 AM	35	70	40	10612	2.28	4.56
11 AM to 3 PM	45	90	80	13644	4.56	18.24
3 PM to 7 PM	40	85	65	12886	3.705	14.82
7 PM to 1 AM	45	90	80	13644	4.56	27.36

Annual energy consumption without VFD : 33288 kWh
Annual energy consumption with VFD : 23717 kWh
Annual energy saving : 9571 kWh
Annual saving in energy cost : Rs 46900
Investment required & payback period : Rs 75000/1.6 yr.

Table 4. Saving potential (supply fan)

Schedule	*Hz*	*CFM %*	*kW %*	*CFM*	*kW required*	*kWh consumed*
9 AM to 11 AM	35	70	40	9282	1.096	2.192
11 AM to 3 PM	45	90	80	11934	2.192	8.768
3 PM to 7 PM	40	85	65	11271	1.781	7.124
7 PM to 1 AM	45	90	80	11934	2.192	13.152

Annual energy consumption without VFD : 16000 kWh
Annual energy consumption with VFD : 11401 kWh
Annual energy saving : 4600 kWh
Annual saving in energy cost : Rs 22540
Initial investment required : Rs 75000
Simple payback period : 3.3 yr.

Coffee shop

- One exhaust fan and one fresh air fan should be operated
- VFDs should be installed at the exhaust fan

Table 5. Saving potential (Exhaust)

Schedule	*Hz*	*CFM %*	*kW %*	*CFM*	*kW required*	*kWh consumed*
6 AM to 11 AM	35	70	40	8048	1.72	8.60
11 AM to 3 PM	45	90	80	10347	3.44	13.76
3 PM to 7 PM	40	85	65	9772	2.80	11.18
7 PM to 1 AM	45	90	80	10347	3.44	20.64

Annual energy consumption without VFD	:	29820 kWh
Annual energy consumption without VFD	:	19776 kWh
Annual energy saving	:	10044 kWh
Annual saving in energy cost	:	Rs 49220
Initial investment required	:	Rs 75000
Simple payback period	:	1.5 yr.

Laundry

- Three exhaust fans should be operated with VFDs

Table 6. Saving potential

Schedule	*Hz*	*CFM %*	*kW %*	*CFM*	*kW required*	*kWh consumed*
9 AM to 11 AM	35	70	40	25732	6.72	33.60
11 AM to 3 PM	45	90	80	33084	13.44	53.76
3 PM to 7 PM	40	85	65	31246	10.92	43.68
7 PM to 1 AM	45	90	80	33084	13.44	80.64

Annual energy consumption without VFD	:	98112 kWh
Annual energy consumption without VFD	:	77263 kWh
Annual energy saving	:	20849 kWh
Annual saving in energy cost	:	Rs 102160
Initial investment required	:	Rs 234000
Simple payback period	:	2.3 yr.

Observation

During last visit it has been observed that except Chinese kitchen VFDs have been installed in rest of the area and Hotel management plans to install this remaining VFD at the earliest.

Lighting systems

The lighting systems at Taj Bengal were reviewed and adopted energy conservation measures were studied to be able to quantify the savings therefrom. Also, plan of action for future implementation of Energy conservation options was studied.

The following measures as recommended in the Energy Audit report were implemented during 2000-2002.

Public area

- The 60W gls lamps in Banquet porch were replaced by 25W gls lamps. The energy saving from this measure was calculated to be 10922 kWh/year.
- The 60W gls lamps in the lobby and restaurant toilets have been replaced by CFLs. The suggested wattage of the lamp as per recommendation was 11W. However it was observed that the replaced wattage is not uniform. The average wattage of replaced lamps was observed to be 18W. Recalculating based on the implemented measure, the annual energy savings is calculated to be 18570kWh/year.
- The 60W gls lamps in the S1 staircase downlighters have been replaced by 10W CFLs. The estimated savings is 4030kWh/year.
- The health club reception has been retrofitted by 15W CFLs. The estimated annual savings are 6106 kWh/year.

The status of the proposed measures which are yet to be implemented are as follows:

Suggested measure	*Predicted energy saving (kWh)*	*Projected investment (Rs.)*	*Comments of Taj Bengal*	*Remarks of Teri*
Separate switching circuit for down lighters in coffee shop	5037	Nil	The coffee shop has been renovated and the lighting scheme has changed	-
Replacement of bracket lamps in Crystal function halls by CFLs	8410	Rs.40,000	The lamp shade is not suitable to be used with CFL	CFL which have similar shape as GLS lamp may be tried out
Replacement of 60W gls by 11W CFLs in Florist and La Patisserie and	4634	9600	The fixture needs modification to accommodate	Fixture modification and lamp retrofit as done in Sales

Suggested measure	*Predicted energy saving (kWh)*	*Projected investment (Rs.)*	*Comments of Taj Bengal*	*Remarks of Teri*
change of luminaires			the CFL	Manager's office may be done
Replace 25W gls below counter lights in Bell captain and Front Desk by 9W CFLs	2562	36000	To be done	-
Use step down transformers with coffer lights in lobby	2545	13305	To be done	-
Replace 300wgls wall washers by 70W Metal halide lamps	21637	74100	Placement of gear boxes for MHL was fouling with the lift shaft	2x36W CFL in wall washer may be used instead.
Use ultrasonic sensors in lobby toilets	4520	35000	CFLs take considerable time to produce its full lumen output and hence use of on/off sensor is not desirable	
Replace 100W gls in Chambers toilet by 15W CFLs	2544	2000	To be done	
Use corridor sensors in connecting passage between health club and swimming pool	7300	16000	-	-
Use 15W CFLs in Business centre	5507	9200	To be done	-
Use CFLs as recommended in Banquet, administrative and sales office	18789	34800	To be done	-
Total	78448 (excld. Coffee shop)	270000		

Service Areas

The linear fluorescent tubelights have been retrofitted with electronic chokes. Onsite measurement of lumen output and power consumption was taken for a fluorescent tubelight with copper choke and a fluorescent tubelight with an electronic choke. While the former consumed 51W the later consumed 38W with identical lumen output as the former resulting in savings of 13W per single lamp fixture. An estimated saving by replacement of chokes in all TL fixtures is **1,02,212 kWh/year.** A further saving is achievable by replacing the existing tubelights by high efficiency tubelights and using step down transformer to operate the same at 200V.

The status of replacement of gls by CFLs in service area is as follows:

Area	*Replacement suggested*	*Action taken*	*kWh saved/year*
Guest elevator pit light	use 9W CFLs	Yet to be implemented	
Lobby Pantry	Use 11WCFLs	Replaced by 18W CFL	2102
Lobby Pantry	Use 11WCFLs	Replaced by 23W CFL	657
Room Service Lobby	Use 11WCFLs	Yet to be implemented	
Junior Gents' sleeping	use 15W CFLs	Replaced by 9W CFL	3119
Security Manager's Office	Use 11W Cfls in downlighters	Replaced by 18W CFLs	584
Ladies' Locker Senior	Use 11W Cfls in downlighters	Replaced by 9W CFLs	8155
Banquet - La Pat (back area)	Use 11W Cfls in downlighters	Replaced by 18W CFLs	1051
S/S Pantry	Use 11W Cfls in downlighters	-	
Chinese Dry Store	Use 15W Cfls in downlighters	Replaced by 20W CFLs	512
Banquet chair store	Use 11W Cfls in downlighters	Yet to be implemented	
Training Room	Use 11W Cfls in downlighters	Replaced by 9W CFLs	1609
TG passage	Use 11W Cfls in downlighters	Replaced by 20W CFLs	1664
s4 staircase	Use 11W Cfls in downlighters	Replaced by 20W CFLs	4993
Chambers kit	Use 15W CFLs	Now using tubelights only	
5th floor food pantry	Use 15W CFLs	Replaced by 9W CFLs	7796

Area	*Replacement suggested*	*Action taken*	*kWh saved/year*
Minibar	Use 11W CFLs	Now using tubelights only	
S-3 stair	Use 15W CFLs	Replaced by 7W CFLs	11160
Dgroom	Use 15W CFLs	Yet to be implemented	
Chinese kit	Use 15W CFLs	Partly replaced by 18W CFLs	1577
N/club kit	Use 15W CFLs	Yet to be implemented	
Sr. locker-gents	Use 15W CFLs	Now using tubelights only	
Comput+back office	Use 15W CFLs	Yet to be implemented	
Eng. Store+back area	Use 15W CFLs	Removed	
		Total	44,979

Additional savings of 63,911 kWh is achievable by making the remaining replacements at a cost of Rs. 40,800.

Guest area

The status of recommended measures in the guest area of the Taj Bengal is as follows:

Suggested measure	*Predicted energy saving (kWh)*	*Projected investment (Rs.)*	*Comments of Taj Bengal*	*Remarks of Teri*
Replace 60W gls in guest corridor by 11W CFL	57420	141000	Yet to be implemented	-
Replace 60W gls in guest toilets by 11W CFL	30500	146800	Yet to be implemented	-
Replace copper chokes by electronic chokes in guest toilet	7060	-	Implemented	
Replace 60W gls in mirror side fixtures by 9W CFLs	34144	164000	The lamp shade is not suitable to be used with CFL	CFL which have similar shape as GLS lamp may be tried out
Provide occupancy sensors in toilets	14406	835200	May not be implemented	-
Provide separate switches for vestibule, mini bar and hanging lamp	-	-	Yet to be implemented	-

However it was observed that about **28kW** additional lighting load has been added due to renovation of guest rooms on 3rd and 4th floors.

Additional measures adopted/planned

- In addition to the above, the 50W halogen lamps in the atrium have been replaced by 20W halogens resulting in 16,470 kWh annual energy savings.
- Judicious operational schedules are followed in each area to reduce wastage.
- It is also proposed to replace the 50W halogens in the guest corridors (lamps used to highlight the terracotta reliefs) by 20W halogens.

Synopsis of implemented and potential measures at Taj Bengal, Kolkata

Area	*Savings achieved annually with the measures implemented since 1999 (kWh)*	*Further savings achievable (kWh)*	*Additional investment required*
Guest area	7060	136470	1287000
Public area	56098	78448	270000
Service area	147191	63911	40800

Building Automation Systems

Hotel has also very ambitious plan to install building automation systems at Taj Bengal, Tata honeywell has carried out a study and they have also submitted a proposal for installing BMS which appears to be very attractive. The total cost of the project is estimated to be approximately Rs 2.4 crores, however any number or quantification of anticipated energy savings have not been mentioned. We very strongly feel that there is a need to change from manual operation to automation but this should be done in phases. We still feel that first hotel should focus on enhancing energy efficiency of equipment and system. When this exercise is completed a fresh study should be made for automation and that should be installed subsequently.